A Recipe for a Light Dilaton from Strong Dynamics

Jay Hubisz 12/6/2013

BNL "Lattice Meets Experiment 2013"

Syracuse University

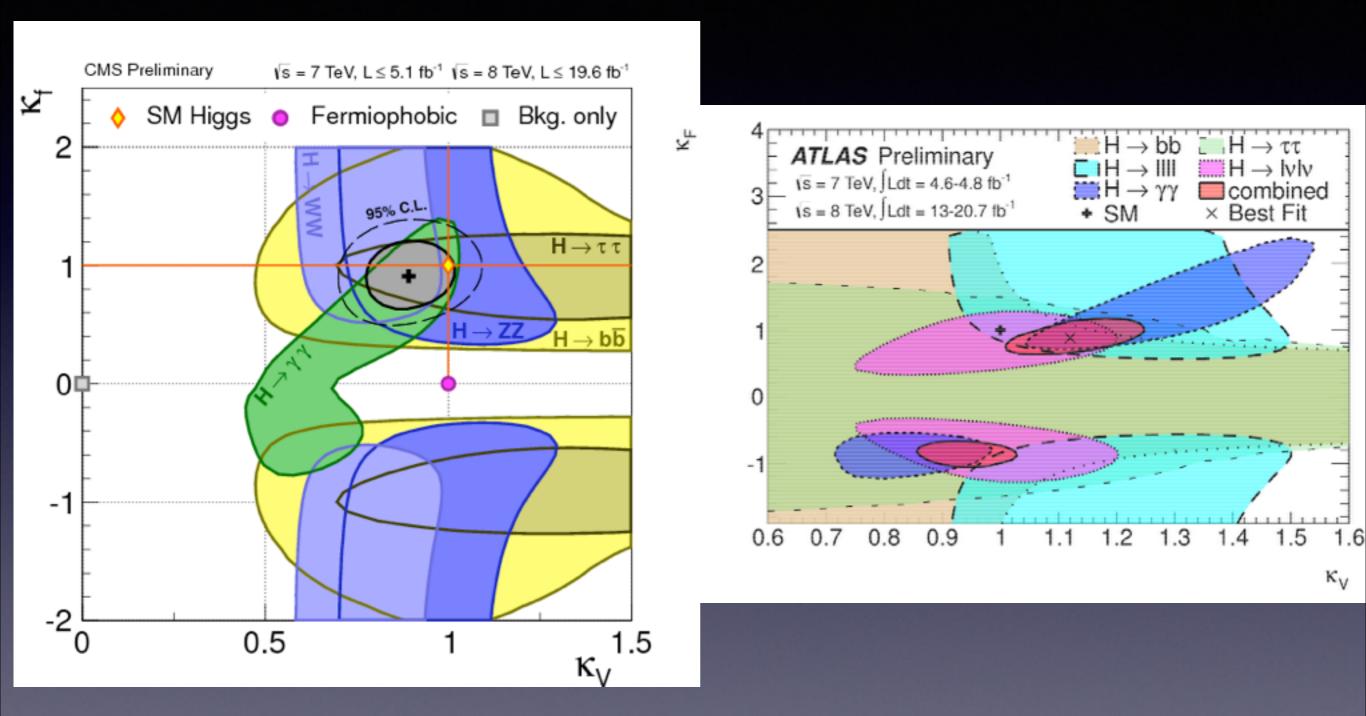


with: Brando Bellazzini, Csaba Csáki, Javi Serra, John Terning

hep-ph:1209.3299

and hep-th:1305.3919

Higgs-like



The resonance is at ~126 GeV and it is SM-Higgs-like 10% -ish deviations still allowed

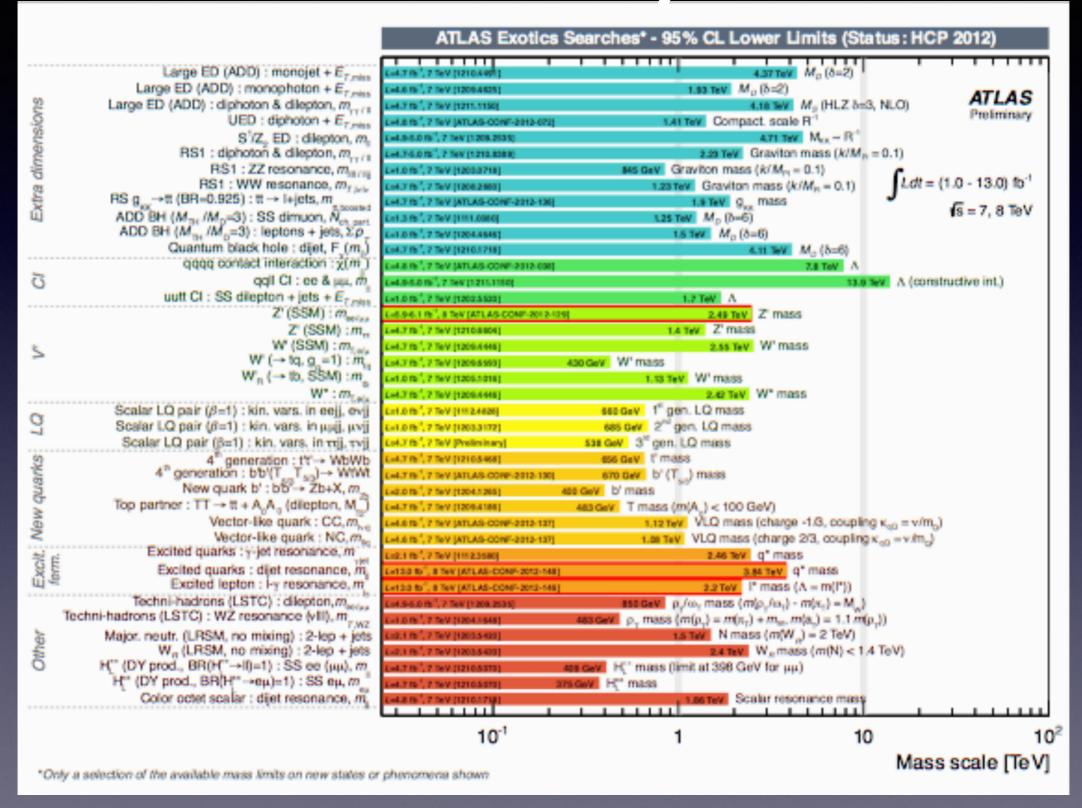
Non-discovery SUSY

		ATLAS SUSY Searches* - 95% CL Lower Limits (Status: Dec 2012)
	MSUGRA/CMSSM: $0 \text{ lep } + j \text{ s} + E_{f, \text{miss}}$	L-6.8 to , 8 TeV (ATLAS-COMP-cond-flag 1.50 TeV Q = Q mass
	MSUGRA/CMSSM: 1 lep + j's + $E_{T,miss}$	E-6.8 to ",8 TeV (ATLAS-CONF-2012-100) 1.24 TeV $\widetilde{\mathbf{q}} = \widetilde{\mathbf{g}}$ mass
99	Pheno model: $0 \text{ lep } + j \text{ 's } + E_{T,miss}$	E-BS BY S THY (ATLAS CONT 2010-100) 1.38 TeV g mass (mil) <2 TeV, loth x 1/2
- 6	Pheno model: $0 \text{ lep } + j \text{ s} + E_{T, \text{min}}$	E-6.8 to ", 6 ToV (ATLAS-CONF-4010-100) 1.38 ToV Q mass (m(2) < 2 ToV, light x) Proliminary
97	Gluino med. $\tilde{\chi}^*$ ($\tilde{g} \rightarrow q \tilde{Q} \tilde{\chi}^*$): 1 lep + j's + $E_{\tau,min}$	E=4.7 to 1,7 TeV [1208.4688] 900 GeV 9 mass (m(x) < 200 GeV, m(x) = (m(x) + m(0)
8	GMSB ([NLSP] : 2 leg (OS) + 1's + E GMSB (* NLSP) : 1-2 r + 0-1 leg + 1's + E	E=4.7 tb ⁻¹ , 7 TeV (1208.4688) (3aryl < 15)
- 8	GMSB (FNLSP): 1-2+ + 0-1 lep + j's + E	E=4.7 fb ⁻¹ , 7 TeV [1310,1314] 1.20 TeV g mass (tan/5 > 20)
- 5	GGM (bino NLSP) : yy + E	E=1.8 (a) TW [1209.0750] Ldt = (2.1 - 13.0) fb ⁻¹
3	GGM (wino NLSP) : $\gamma + lep + E^{\Gamma, min}$	E-EB BO', T THY (ATLAS CONFIDER 1919 1940) 619 GeV. 9 MASS
	GGM (higgsino-bino NLSP) : $\gamma + b + E_{T, non}^{T, non}$	E=E 6 (7 TW (1211.1167) 000 GeV (2 mass (*(√,1) > 220 GeV) (S = 7, 8 TeV
	GGM (higgsino NLSP) : $Z + jets + E_{T,nim}$	LISE TO STATE (ATLAS -CONF-3010-152) 690 GeV g mass (m) 1 > 200 GeV)
	Gravitino LSP : 'monojet' + E _{T,ries}	E-no.s rs.", a new (ATLAS-CONF-2012-1 KIT) 645 GeV F" SCOLO ((n)C) > 10 ° eV)
8.8	ğ→bbχ (virtualb) : 0 lep + 3 b-j's + E _{τ,ress}	L=12.8 fb. ¹ , 8 feV (ATLAS CONF-2012 149) 1.28 feV g mass (mg. ²) < 200 GeV)
g 8	$g \rightarrow f(\chi)$ (virtual t) : 2 lep (SS) + j's + $E_{T,min}$	Ens.8 to 1,6 TeV (ATLAS-CONF-2010-105) aso Dav g mass (mg2) < 300 GeV)
8.3	$g \rightarrow t f \chi$ (virtualt): 3 lep + j's + $E_{T,min}$	ginds (etc.) con as a section of the control of the
3rd gen. sq	g→tfy (virtualt) : 0 lep + multi-j's + E _{r,max}	E-6.8 to (art. As-construction 1.00 TeV g mass (n/g) < 300 GeV) 7 TeV results E-6.8 to (art. As-construction 1.00 TeV g mass (n/g) < 300 GeV)
	— d→itX (Altitral () : 0 Hib + 2 0-18 + E ^{± mins}	
10 0	bb, b, \rightarrow by : 0 kp + 2-b-jets + $E_{T,min}$	
8 6	$bb, b, \rightarrow t\overline{\chi}^*: 3 \text{ lep } + j^*s + E_{\gamma \text{ sime}}$ If (light), $t \rightarrow b\overline{\chi}^*: 1/2 \text{ lep } (+b - jet) + E_{\gamma}$	E-min or n , a new particle cone-participation of $mass(m(x_1^2) = 2m(x_2))$ E-E-Min new participation of $mass(m(x_1^2) = 66 \text{ GeV})$
3rd gen, squarks direct production	II (medium), I→b\(\overline{\chi}\); 1 lep + b-jet + E _{y-min}	E-13.0 fb. ¹ , 8 TeV [ATLAS-CONF-2012-180] 180-385 GeV [MS[88] (mG ²) = 0 GeV, mG ²) = 150 GeV)
2.8	$\widetilde{\mathrm{ff}}$ (medium), $\widetilde{\mathrm{f}} \rightarrow b\widetilde{\chi}^*$: 2 lop + $E_{T,\mathrm{min}}$	E-10.0 fb., a TeV [ATLAS-CONF-2012-167] 150-440 GeV
8 5	$0, 1 \rightarrow 0, 1 \rightarrow 0, 1 \rightarrow 0$ $0, 1 \rightarrow 0, 1 \rightarrow 0, 1 \rightarrow 0$ $0, 1 \rightarrow 0, 1 \rightarrow 0, 1 \rightarrow 0$ $0, 1 \rightarrow 0, 1 \rightarrow 0, 1 \rightarrow 0$	E=13.0 To 1,8 TeV (ATLAS-CONF-2012-100) 200-600 GeV T mass (m/2) = 0
P 3	# 1-40 : 0/1/2 lon (+ h-lots) + F-	E=4.7 to", 7 TeV (1206.1447,1206.2590,1208.4186) #80 465 GeV (mass (H(x)) = 0)
19 0	ff, t→ty : 0/1/2 lep (+ b-jets) + E _{7,000} ff (natural GMSB) : Z(→tl) + b-jet + E	E=2.1 to 7 TW [1204.0730] 310 GeV 1 mass (115 < m(2) < 250 GeV)
	$((, -1)\overline{\chi}_{\alpha}: 2 \text{ lep} + E_{T, \text{ress}}^{T, \text{ress}})$	E=4.7 % ¹ , 7 TeV [1208.2894] 85-195 GeV mass ($\pi(\tilde{\chi}^0) = 0$)
> 3	$(\overline{\chi}, \overline{\chi}, \overline{\chi}, \rightarrow h_1(\overline{v}) \rightarrow h_2(\overline{\chi}, : 2 \text{ lop} + E_{T, \text{min}})$	End 7 % 7 TeV [1206.2884] 110-345 GeV $\widetilde{\chi}_{c}$ mass $(m(\widetilde{\chi}_{c}^{2}) < 10 \text{ GeV}, m(\widetilde{\chi}_{c}) = \frac{1}{2}(m(\widetilde{\chi}_{c}^{2}) + m(\widetilde{\chi}_{c}^{2}))$
EW	$\overline{\chi}, \overline{\chi} \rightarrow (\sqrt{1}(\overline{v}v), \overline{v}), (\overline{v}v): 3 \text{ lep } + E$	E-millors*, a TeV [ATLAS-CONF-2012-154] Sep GeV $\widetilde{\chi}$, mass $(m\widetilde{\chi}) = m\widetilde{\chi}^2$, $m(\widetilde{\chi}) = 0$, $m(\widetilde{\chi}) = 0$, $m(\widetilde{\chi}) = 0$ as above)
		E=13.0 Ib ⁻¹ , 8 TeV (ATLAS CON-2012-194) S40-295 GeV X, MRSS (m(x)) = m(x), m(x) = 0, sleptons decoupled)
Th	$\chi \chi \rightarrow W^* \chi Z^* \chi^* : 3 \text{ lep } + E_{T, \text{max}}$ Direct χ , pair prod. (AMSB) : long-lived χ ,	E=4.7 6°, 7 TeV [1210,3882] 220 GeV X, M8SS (1 < 10 m)
2 3	Stable g R-hadrons : low \$, \$y (full detector)	L=4.7 to*, 7 TeV [1211.1597] 985 GeV g mass
6.5	Stable f R-hadrons : low β, βy (full detector)	E=67 to*, 7 two (1211.1597) 683 GeV 1 mass
Long-fiver	GMSB: stable t	E=6.7 to 7 TeV [1211.1997] 300 GeV T MRSS (5 < tar(5 < 20)
-		Ene.4 (6)", 7 TeV (12/0,745)) 700 GeV Q mass (0.3×10" < \(\lambda_{eq.1}^2\) < 1.5×10", 1 mm < ct < 1 m, \(\text{g}\) decoupled)
	LFV : pp→v,+X, v,→e+μ resonance	E=6.6 to 7.7 TeV (Preliminary) 1.61 TeV V _c TIBSS (X ₁₀₁ =0.10, X ₁₀₂ =0.05)
	LFV: $pp \rightarrow \tilde{v}_{+} + X_{+} \tilde{v}_{-} \rightarrow e(\mu) + \tau$ resonance	E=E8 to , 7 TeV (Pessionary) 1.10 TeV. V ₂ mass (K ₂₁₇ 0.10, A ₁₀₃₄ 0.05)
PP.V	Bilinear RPV CMSSM: 1 lep + 7 j's + $E_{7,miss}$	E=4.7 b ⁻¹ , 7 TeV [ATLAS-CONF-0010-140] 1.2 TeV $\tilde{q} = \tilde{g}$ mass $(c_{T,pp} < 1 \text{ nm})$
Œ	$\chi_{\chi_{\alpha}} \chi \rightarrow W \chi_{\alpha}, \chi_{\alpha} \rightarrow eev_{\alpha}, e\mu v_{\alpha} : 4 lep + E_{\chi_{\alpha} res}$	Emissions*, a TeV (ATLAS-CONF-2012-153) 700 GeV (X, mass (m(X)) > 300 GeV, k ₁₀₁ or k ₁₀₂ > 0)
	$\widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi} \rightarrow W\widetilde{\chi}_{0}^{2}, \widetilde{\chi} \rightarrow eev_{\mu}, e\mu v_{\mu} : 4 lep + E_{T, min}$ $(\widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi}, \widetilde{\chi}, e\mu v_{\mu}, e\mu v_{\mu} : 4 lep + E_{T, min})$	E-13.0 Tb. $(m_Z^2) > 100 \text{ GeV}, m_{A} = m_{A} = m_{A} = 0$ (m $_{A} = 0$) at the particle of the particle o
	g → ggg : 3-jet resonance pair	E-E-B BD*, 7 YeV [1210.4813] 666 GeV. g mass
MATE	Scalar gluon : 2-jet resonance pair MP interaction (D5, Dirac χ) / monojet + E	E=4.6 to*, 7 TeV [1210.4826] 100.287 GeV Sglu01 mass (inc), limit from 1110.2000)
WIMP interaction (D5, Dirac χ) : 'monojet' + E'		
10°1 1 10		

^{*}Only a selection of the available mass limits on new states or phenomena shown. All limits quoted are observed minus 1 or theoretical signal cross section uncertainty:

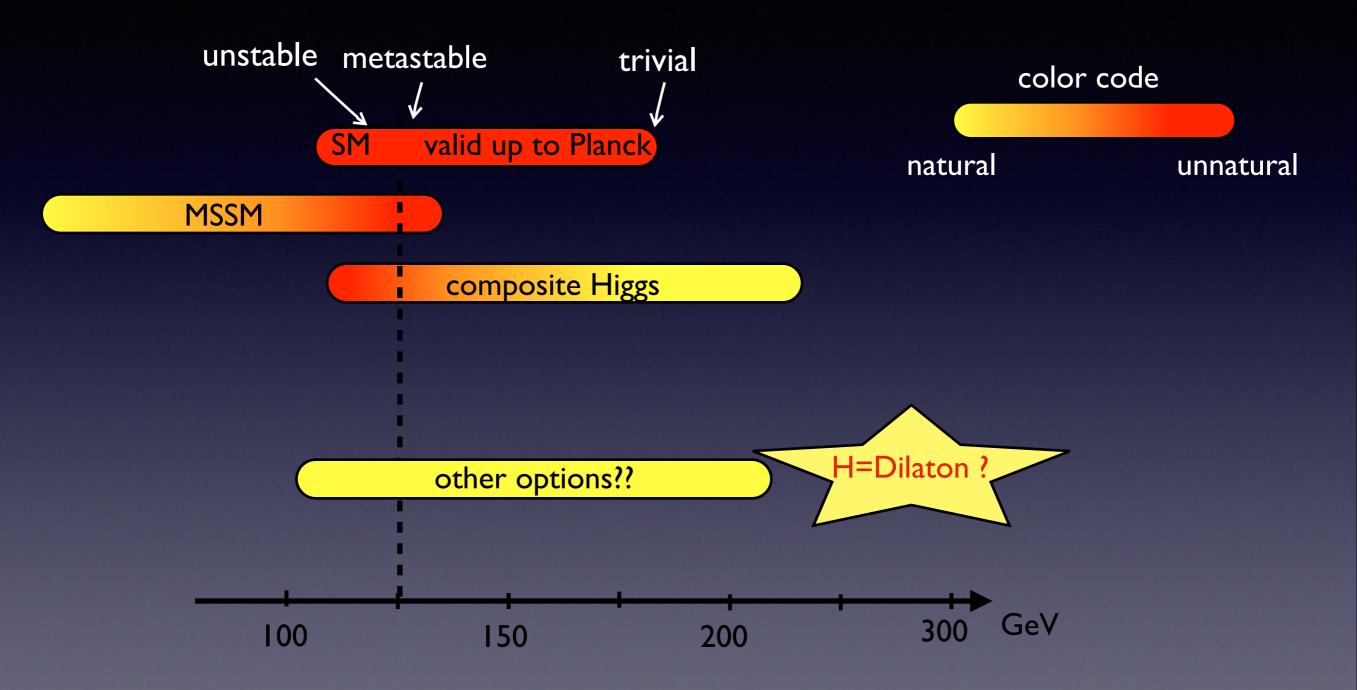
Mass scale [TeV]

Non-discovery exotics



+electroweak - Gap to new physics - Natural?

Status of light scalars



All models seem to be under strain

S.B. Scale invariance

Dilatations:

$$x \to x' = e^{-\alpha}x$$

Operators transform:

$$\mathcal{O}(x) \to \mathcal{O}'(x) = e^{\alpha \Delta} \mathcal{O}(e^{\alpha} x)$$

CFT operator gets VEV:

$$\langle \mathcal{O}(x) \rangle = f^{\Delta}$$

Corresponding goldstone boson:

$$\sigma(x) \to \sigma(e^{\alpha}x) + \alpha f$$

Non-linear realization in effective theory:

$$f \to f \chi \equiv f e^{\sigma/f}$$

Restores symmetry to LEEFT

Dilaton Couplings

- Presume a strongly coupled conformal sector coupled to weak elementary sector
- Strong sector has SBSI
- derive interactions of mass eigenstates with dilaton

Dilaton-Composite Couplings

Longitudinal components of W,Z, 3rd generation

$$\mathcal{L}_{CFT}^{UV} = \sum g_i \mathcal{O}_i^{UV}$$

UV lagrangian Allow small explicit breaking

$$[g_i] = 4 - \Delta_i^{UV}$$

In IR, different dof

$$\mathcal{L}_{CFT}^{IR} = \sum_{j} c_j \left(\Pi g_i^{n_i} \right) \mathcal{O}_j^{IR} \chi^{m_j}$$

$$m_j = 4 - \Delta_j^{IR} - \sum_i n_i (4 - \Delta_i^{UV})$$

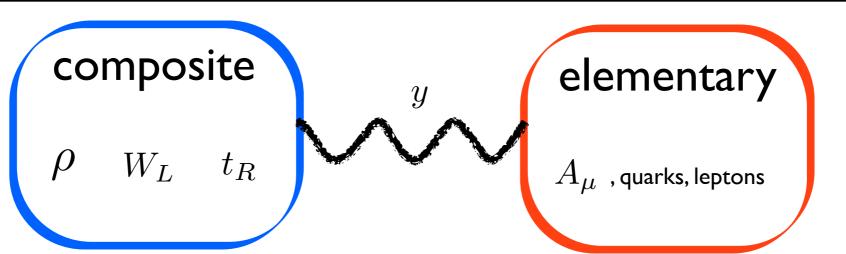
compensate

Single power of exp. breaking:

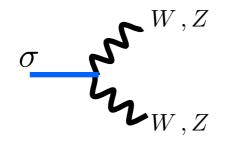
r of exp. breaking:
$$\mathcal{L}_{breaking}^{IR} = \sum_{j} c_{j} g_{i} \left(\Delta_{i}^{UV} - \Delta_{j}^{IR} \right) \mathcal{O}_{j}^{IR} \frac{\sigma}{f}$$
No exp. breaking: $\mathcal{L}_{symmetric}^{IR} = \sum_{j} c_{j} \left(4 - \Delta_{j}^{IR} \right) \mathcal{O}_{j}^{IR} \frac{\sigma}{f}$

rescaled tree-level SM SM beta-functions
$$\frac{\sigma}{f}T^{\mu}_{\mu}=\frac{v}{f}\sigma\left\{\left[2m_W^2W_{\mu}^2+m_Z^2Z^2+m_{\psi}\psi\psi\ldots\right]+2\frac{\beta_s}{g}G_{\mu\nu}^2+2\frac{\beta}{e}F_{\mu\nu}^2\right\}$$

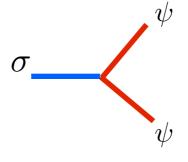
Couplings - Summary



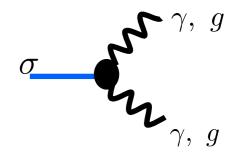
overall rescaling anomalous dim. beta-functions
$$\mathcal{L} = \frac{v}{f} \sigma \left\{ \left[2m_W^2 W_\mu^2 + m_Z^2 Z^2 + m_\psi \psi (1+\gamma) \psi \dots \right] + 2(\beta_{UV} - \beta_{IR})/g \, F_{\mu\nu}^2 \right\}$$



$$SM imes rac{v}{f}$$



$$SM imes rac{v}{f} (1 + \gamma)$$



$$\frac{v}{f}(\beta_{UV} - \beta_{IR} + loops)$$

Experiment

- If the 125 GeV scalar is a dilaton we require:
 - v ~ f (Alignment of electroweak vev with CFT operator vev)
 - moderate anomalous dimensions for heavy flavor (b, tau) and flavor symmetry
 - Significant gap to scale of strong dynamics

Can it be light?

The Dilaton Quartic

Most general terms invariant under dilatations:

$$\mathcal{L}_{eff} = \sum_{n,m \geqslant 0} \frac{a_{n,m}}{(4\pi)^{2(n-1)} f^{2(n-2)}} \frac{\partial^{2n} \chi^m}{\chi^{2n+m-4}}$$

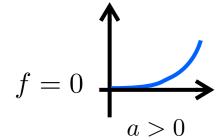
$$= -a_{0,0} (4\pi)^2 f^4 \chi^4 + \frac{f^2}{2} (\partial_{\mu} \chi)^2 + \frac{a_{2,4}}{(4\pi)^2} \frac{(\partial \chi)^4}{\chi^4} + \dots$$

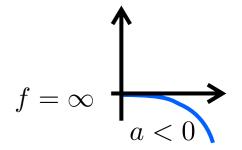
dilaton quartic

$$S = \int d^4x \frac{f^2}{2} (\partial \chi)^2 - af^4 \chi^4 + \text{higher derivatives}$$

Obstruction to SBSI:

- $a > 0 \rightarrow f = 0$ (no breaking)
- $a < 0 \rightarrow f = \infty$ (runaway)
- $a = 0 \rightarrow f = anything (flat direction)$





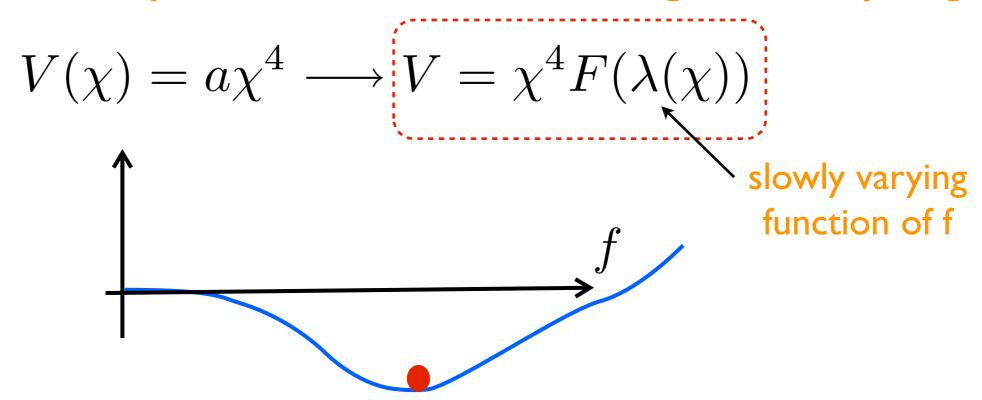
$$f = ?$$

$$a = 0$$

Near-Marginal Deformation

$$\delta S = \int d^4x \lambda(\mu) \mathcal{O}$$

Quartic has dependence on near marginal coupling:



Deformation can stabilize f away from origin

$$V' = f^3 \left[4F(\lambda(f)) + \beta F'(\lambda(f)) \right] = 0$$

The Dilaton Mass

Expanding the potential:

$$m_{dil}^2=f^2\beta\left[\beta F''+4F'+\beta' F'\right]\simeq 4f^2\beta F'(\lambda(f))=-16f^2F(\lambda(f))$$
 small, so dilaton is light, right?

F is the cosmological constant in f units:

$$F_{NDA} \sim \frac{\Lambda^4}{16\pi^2 f^4} \sim 16\pi^2$$

Need large β to find minimum $V' = f^3 [4F(\lambda(f)) + \beta F'(\lambda(f))] = 0$

Theory not conformal at scale f - no light dilaton

$$m_{dil}^2 \sim 256\pi^2 f^2 \sim \Lambda^2$$
 3 TeV not 125 GeV

OR we can tune away the quartic to get a near flat-direction

Goldberger-Wise

Brane values of GW scalar field

$$V = f^4 \left\{ (4+2\epsilon) \left[v_1 - v_0 \left(fR \right)^\epsilon \right]^2 - \epsilon v_1^2 + \delta a + O(\epsilon^2) \right\} = f^4 F(f)$$
 bulk potential

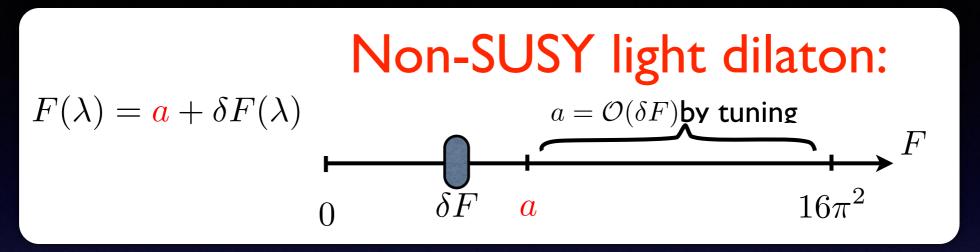
scalar - near marginal coupling in CFT

$$f = \frac{1}{R} \left(\frac{v_1 + \sqrt{-\delta a/4}}{v_0} + O(\epsilon) \right)^{1/\epsilon}$$

yields hierarchy for $\sqrt{-\delta a/4} \lesssim v_1$

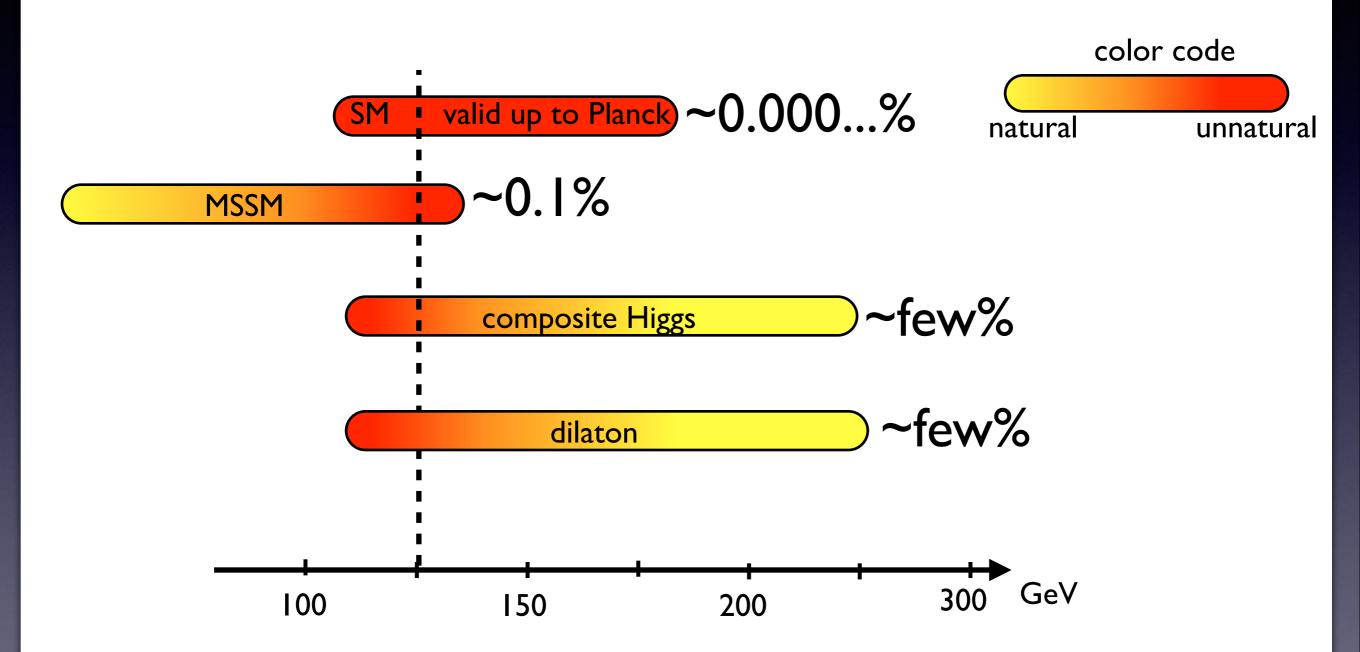
tuning:
$$\Delta = \frac{a}{|\delta a|} \gtrsim \frac{4\pi^2}{v_1^2}$$
 typically order 1000

Light Dilaton?



- Generically, dilaton is not light unless the quartic is suppressed relative to NDA
- To get a light dilaton, need flat direction in vicinity of near-zero in β -function or large N
- While this is natural in SUSY theories, it is not the case in non-supersymmetric ones
- When dilaton is light, does not seem very Higgslike

The EVVSB line-up



dilaton and composite Higgs in a similar strained state

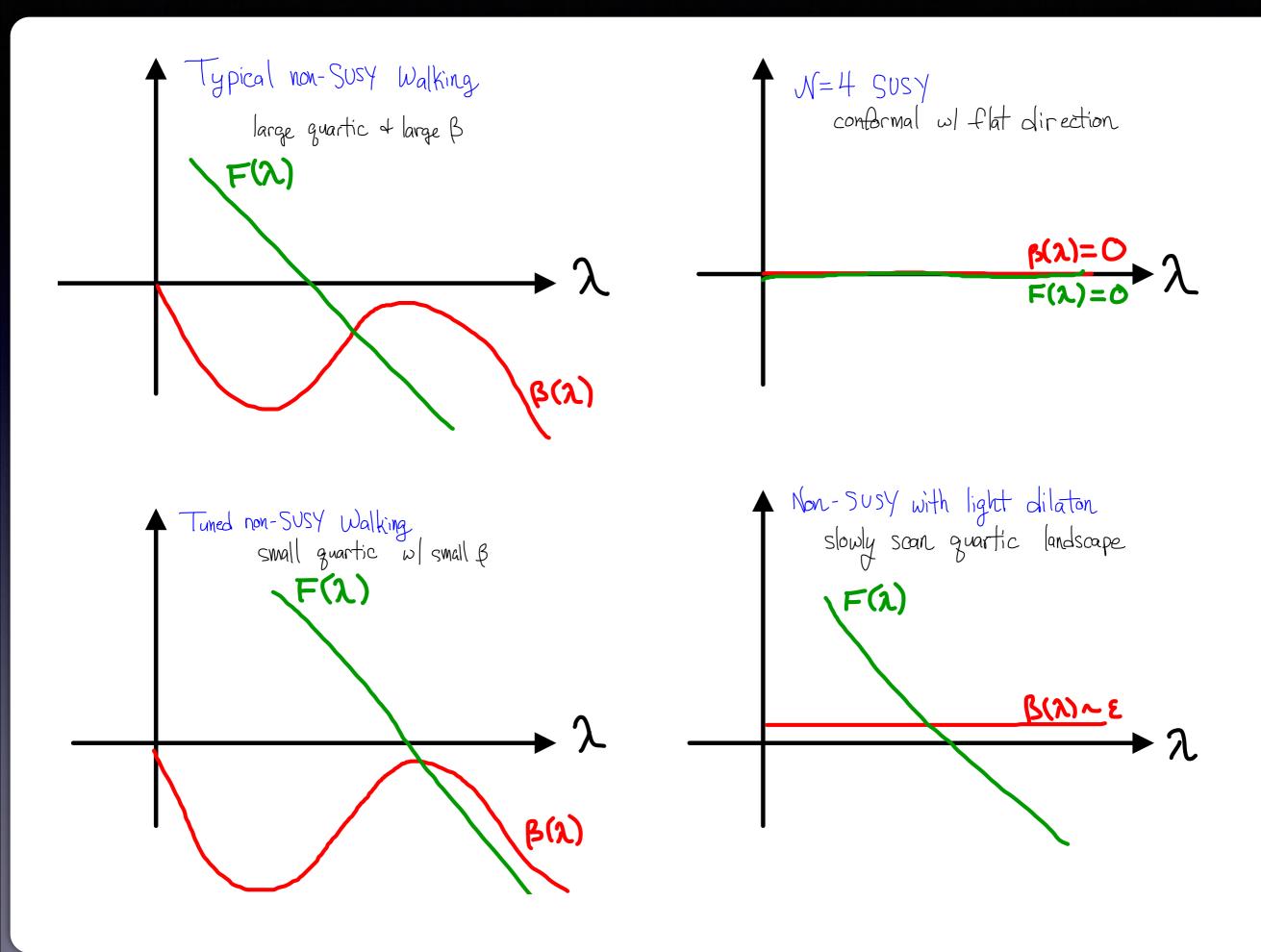
A way out?

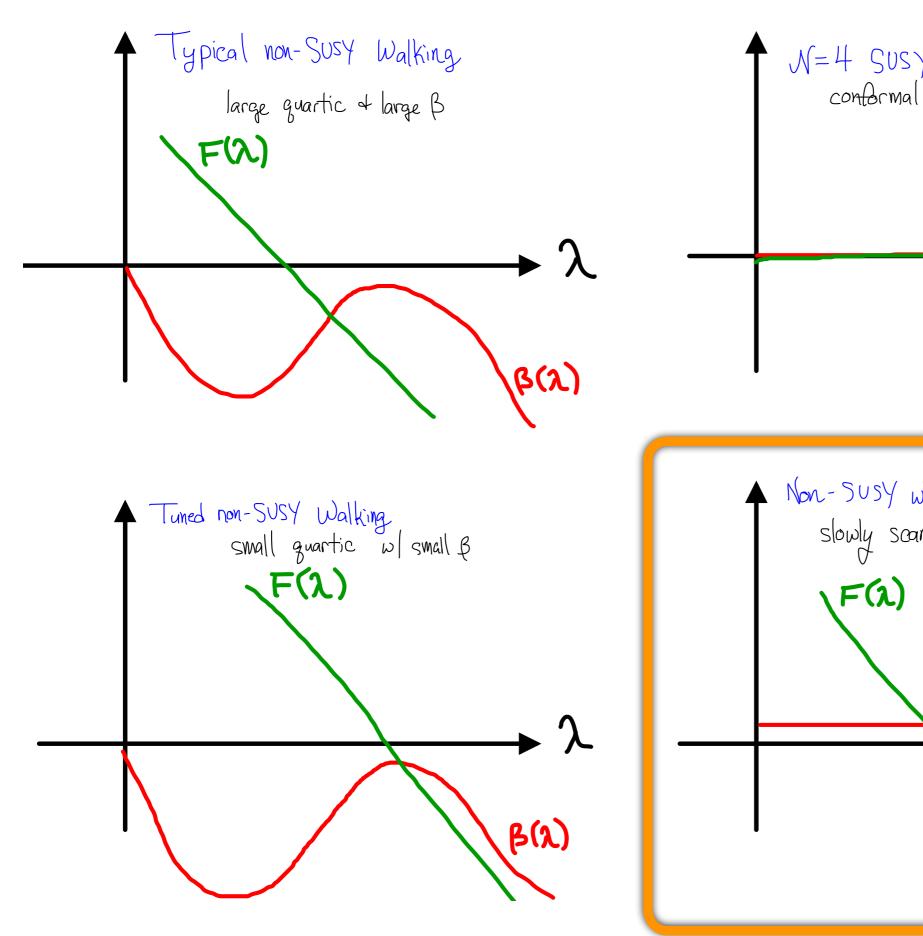
CPR idea (Contino - Pomarol - Rattazzi)

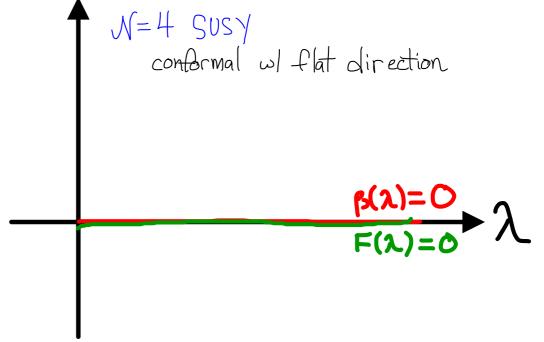
• $F(\lambda)$ generically large, but if λ near marginal for large range of λ , theory will scan over F with scale

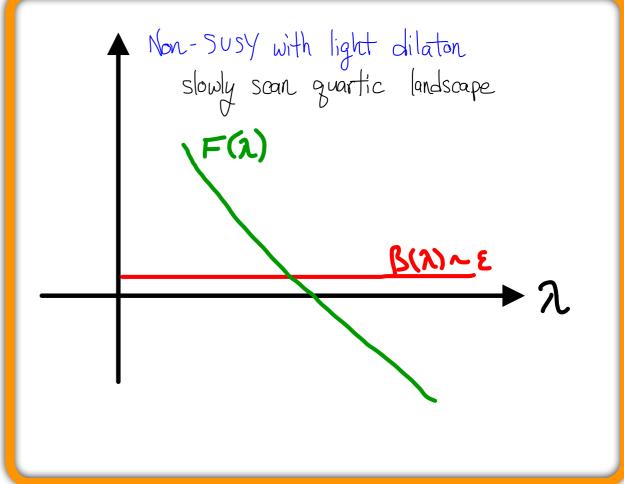
$$\frac{d\lambda}{d\log\mu} = \beta(\mu) \equiv \epsilon \ll 1$$

- ullet large F will not generate SBSI minimum when F \sim 0
- dilaton mass proportional to ε



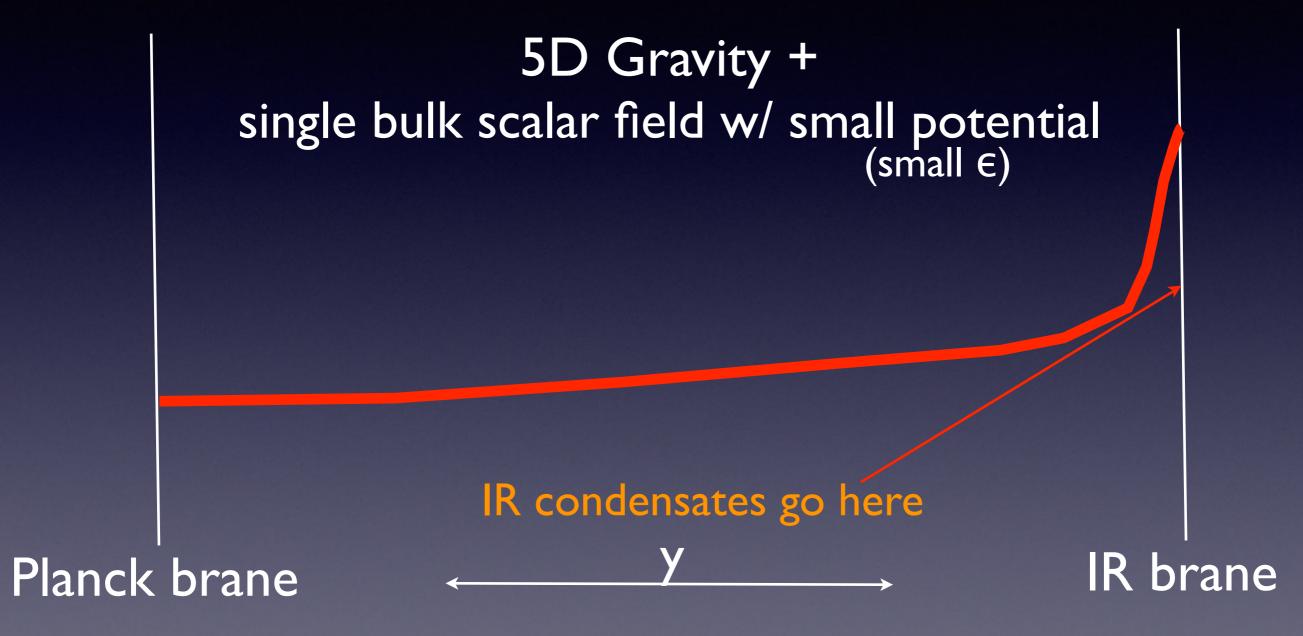






A Holographic Realization

Holography and light dilatons



system responds by shifting Planck scale - CC stays zero

Holography and light dilatons

$$S = \int d^5x \sqrt{g} \left(-\frac{1}{2\kappa^2} \mathcal{R} + \frac{1}{2} g^{MN} \partial_M \phi \partial_N \phi - V(\phi) \right) + \int d^4x \sqrt{g_0} V_0(\phi) + \int d^4x \sqrt{g_1} V_1(\phi)$$

AdS/CFT:

small $\beta \Leftrightarrow$ nearly constant $V(\Phi)$

$$V(\phi) = \Lambda_5 + \epsilon f(\phi)$$

Metric Ansatz - flat 4D slices

$$ds^2 = e^{-2A(y)}dx^2 - dy^2$$

ID of scale - warping

$$\mu = A'(y=0)e^{-A(y)} = \frac{1}{R}e^{-A(y)}$$

Bulk EOM

$$4A'^{2} - A'' = -\frac{2\kappa^{2}}{3}V(\phi)$$

$$A'^{2} = \frac{\kappa^{2}\phi'^{2}}{12} - \frac{\kappa^{2}}{6}V(\phi)$$

$$\phi'' = 4A'\phi' + \frac{\partial V}{\partial \phi}$$

Boundary conditions:

$$2A'|_{y=y_0,y_1} = \pm \frac{\kappa^2}{3} V_1(\phi)|_{y=y_0,y_1}$$
$$2\phi'|_{y=y_0,y_1} = \pm \frac{\partial V_1}{\partial \phi}|_{y=y_0,y_1},$$

Holography and light dilatons

Imposing bulk eom on V_{bulk} gives pure boundary term

$$V_{bulk} = \frac{2}{\kappa^2} \int_{y_0}^{y_1} dy e^{-4A(y)} (4A'^2 - A'') = -\left[\sqrt{g} \frac{2}{\kappa^2} A'\right]_0^1$$

Other similar terms from brane potentials and metric jump conditions

$$\chi \equiv e^{-A(y_1)}$$

Dilaton effective potential:

$$V_{IR} = \chi^4 \left[V_1 \left(\phi \left(A^{-1} (-\log \chi) \right) \right) + \frac{6}{\kappa^2} A' \left(A^{-1} (-\log \chi) \right) \right] = \chi^4 F(\lambda(\chi))$$

Automatically minimized when BC's satisfied

Precisely of form quartic modulated by chi dep. of F

Constant Bulk Potential

$$V(\phi) = \Lambda_{(5)} = -\frac{6k^2}{\kappa^2}$$

Exactly Solvable:

$$A(y) = -\frac{1}{4} \log \left[\frac{\sinh 4k(y_c - y)}{\sinh 4ky_c} \right]$$

Singularity at y_c

$$\phi(y) = -\frac{\sqrt{3}}{2\kappa} \log \tanh[2k(y_c - y)] + \phi_0$$

Impose UV Boundary Conditions: fix y_c and Φ_0

$$V_i(\phi) = \Lambda_i + \lambda_i(\phi - v_i)^2$$

Boundary conditions generically satisfied for finite y_c

Large AdS deformation!

$$ds^2 = \sqrt{\frac{\sinh 4k(y_c - y)}{\sinh 4ky_c}} dx^2 - dy^2$$

But Still Scale Invariant

explicitly broken by dynamical gravity - finite μ_0

$$V_{UV} = \mu_0^4 \left(\Delta_0 + \mathcal{O}(\chi^8/\mu_0^8) \right)$$

Pure UV Contribution to CC term

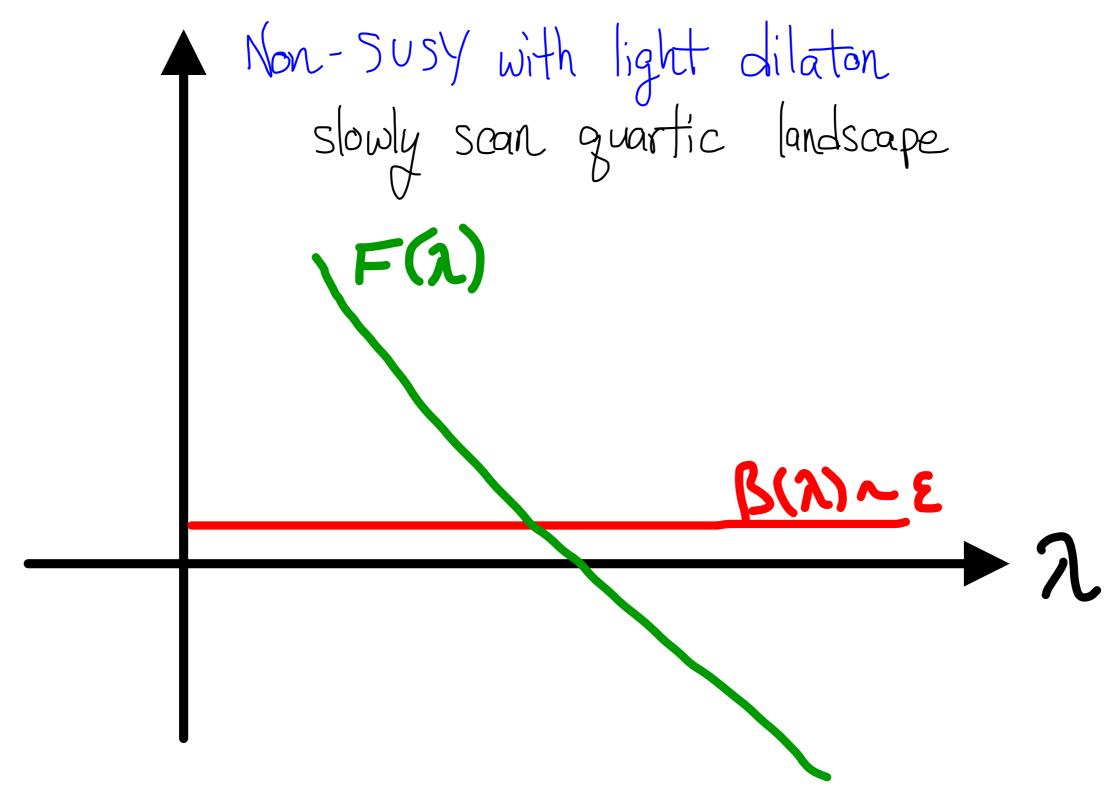
$$V_{IR} = \chi^4 \left(a(v_0) + \mathcal{O}(\chi^4/\mu_0^4) \right)$$

Pure dilaton quartic

Singularity at y_c corresponds to condensate of marginal operator in CFT - spont. breaking of SI

Dilaton quartic is from composite condensates (IR tension) and the condensate of this operator

$$a(v_0) = \Lambda_1 + \frac{6k}{\kappa^2} \cosh\left(\frac{2\kappa}{\sqrt{3}}(v_1 - v_0)\right)$$
 can tune this away by adjusting v_0



If β =0, no scanning, have to tune condensates against each other - special value of coupling

Including a bulk mass

CFT coordinates

$$t = \log \mu R = -A(y)$$

Use bulk eom to eliminate A(y):

$$\ddot{\phi} + \left[4\dot{\phi} + \frac{6}{\kappa^2} \frac{\partial \log V}{\partial \phi}\right] \left[1 - \frac{\kappa^2}{12} \dot{\phi}^2\right] = 0$$

neglecting non-linear terms (small back-reaction):

$$\ddot{\phi} + 4\dot{\phi} - 4\epsilon\phi = 0 \qquad \phi(t) \approx Ae^{-(4+\epsilon)t} + Be^{\epsilon t}$$
 slowly running piece

now Φ_0 scans - finds minimum when quartic small

Boundary layer theory - asymptotic matching

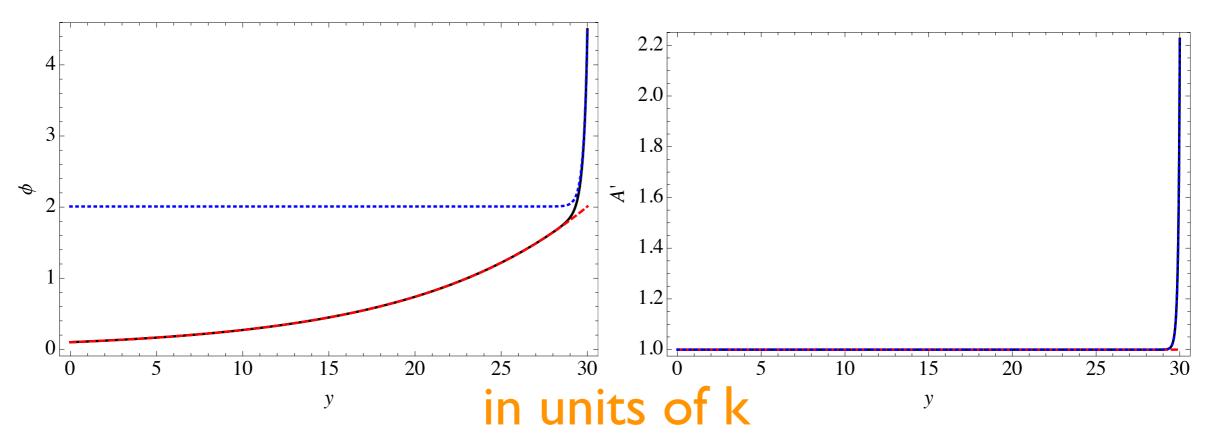


Figure 2: Left, bulk scalar profile: ϕ_{full} (solid black), ϕ_r (dashed red), and ϕ_b (dotted blue). Right, effective AdS curvature, A'(y): same color code.

Two regions

$$\ddot{\phi} + \left[4\dot{\phi} + \frac{6}{\kappa^2} \frac{\partial \log V}{\partial \phi}\right] \left[1 - \frac{\kappa^2}{12} \dot{\phi}^2\right] = 0$$

Backreaction term Eventually, back-reaction comes to dominate

IR Universality - condensate of d ~ 4 operator

(IR region has same behavior as constant bulk potential)

Full matched solution

(boundary layer theory/asymptotic matching)

$$\phi_{\text{full}} = v_0 e^{\epsilon k(y-y_0)} - \frac{\sqrt{3}}{2\kappa} \log\left(\tanh\left(2k(y_c - y)\right)\right)$$

The Outcome

You get a hierarchy:

$$\frac{\langle \chi \rangle}{\mu_0} = \left(\frac{v_0}{v_1 - \operatorname{sign}(\epsilon) \frac{\sqrt{3}}{2\kappa} \operatorname{arcsech}(-6k/\kappa^2 \Lambda_1)}\right)^{1/\epsilon} + O(\epsilon)$$

Condensate balances other contributions naturally (IR brane tension mistune)

Dilaton comes out light (with suppressed CC):

$$m_{\rm dilaton}^2 \sim \epsilon f^2$$
 $\Lambda_{\rm CC} \sim \epsilon f^4$

UV value still tuned to be small

- only erase condensate contributions

v/f? - Lessons from Holgraphy

What is f?

$$f^{(RS)} = \frac{1}{R'} \sqrt{12(M_*R)^3} = \frac{N_{\text{CFT}}}{R'}$$

Higgsless dilaton:

$$\frac{v}{f^{(RS)}} = \frac{2}{g} \frac{1}{N\sqrt{\log \frac{R'}{R}}}$$

Heavy IR Higgs

$$\frac{v}{f^{(RS)}} = \frac{vR'}{N}$$

Far too small to be consistent with LHC data Suppressed by large N (perturbativity of 5D model)

It does suppress mass (once quartic tuning imposed):

Goldberger-wise:
$$m_{dil}^2 = \frac{16}{NR'^2} \left(v_1 \sqrt{-\delta a} - \frac{\delta a}{2} \right) \epsilon$$

Large N Typical Walking

$$m_d^2 \sim \frac{\Lambda^2}{N}$$

$$\frac{v}{f} \sim \frac{1}{N}$$

Small N Typical Walking

$$m_d^2 \sim \Lambda^2$$

$$\frac{v}{f} \sim 1?$$

Large N "Scanning"

$$m_d^2 \sim \frac{\epsilon}{N} f^2$$

$$\frac{v}{f} \sim \frac{1}{N}$$

Small N "Scanning"

$$m_d^2 \sim \epsilon f^2$$

$$\frac{v}{f} \sim 1?$$

Conclusions

- If the 126 GeV resonance is a dilaton, it must be uncannily Higgslike
- Tensions: EWP, Flavor, mass tuning, Higgs fits
 - crucial to pin down properties with more data
- Light dilatons:
 - ID'd class of potential theories "scan" landscape of quartics to achieve SBSI (CPR)
 - non-supersymmetric models with light dilatons seem very special small β for large range of strong coupling